Development Of A Thermal Protection System Mass Estimating Relationship Based on FIAT Predictions

Abstract for IPPW-8 June, 6-10, 2011

S. Sepka[1], J. O. Arnold[2], E. Venkatapathy[3] and K. Trumble[4]

Of major interest in the design of a thermal protective system (TPS) for entry into Earth's atmosphere is the space ship's required amount of heat shield material for safe passage. Presented here is the development of mass-estimating-relationships (MERs) used to predict the amount of TPS material to keep its back face temperature of the ablator below 250°C, which is considered to but the typical maximum temperature an epoxy can withstand when holding the TPS to its aeroshell. The MERs were developed based upon FIAT[i] predictions at the stagnation point for a range of possible flight paths that resulted in the creation of 840 trajectories using DPLR[ii]. Variables considered in this MER correlations included entry flight path angle, entry velocity, ballistic coefficient, heat load, peak heat flux, and maximum surface pressure. It will be shown that entry flight path angle and heat load had the greatest sensitivity to required thickness. Multiple MERs were developed using the PICA[iii] and one MER was developed for Carbon Phenolic [3]. Accuracy of the PICA MERs to FIAT prediction were within 13% at one standard deviation (SD), while the Carbon Phenolic MER had an accuracy of 7% at one SD. How the MERs were created, their modeling assumptions and limitations, and the applicability of these MERs will be discussed.

[1] Senior. Research Scientist, ERC Corporation, Thermal Protection Materials and Systems Branch, NASA Ames Research Center, MS-234-1, Moffett Field, CA, 94035 (Tel. 650-604-3833).
[2] NASA Ames IPA, Entry Systems and Technologies Division (Code TS), MS 229-3
[3] Chief Technologist, Entry Systems and Technologies Division (Code TS), MS 229-3
[4] Research Scientist, NASA Ames Research Center, Reacting Flow Environments Branch (Code TSA), MS 230-2,

References

[i] Chen, Y.-K., and Milos, F. S., "Fully Implicit Ablation and Thermal Analysis Program (FIAT)," Journal of Spacecraft and Rockets,Vol. 36, No. 3, pp 475-483, May–June 1999

[ii] Wright, M.W., White, T., and Mangini, N., Data Parallel Line Relaxation (DPLR) Code User Manual Acadia Version 4.01.1, NASA/TM-2009-215388, October 2009.

[iii] Tran, H., Johnson, C, Rasky, D., Hui, F., Chen, Y.-K., and Hsu, M., "Phenolic Impregnated Carbon Ablators (PICA) for Discovery Class Missions," AIAA Paper 96-1911, June 1996.